CHAPTER 2

PRINCIPLES OF RECOVERY

GENERAL

Recovery is performed to:

- Retrieve damaged equipment for repair and return to use.
- Retrieve abandoned equipment for further use.
- Prevent enemy capture of equipment.
- Ensure recovery assets are equipped with communications.
- Obtain enemy materiel and records for intelligence purposes or for use by US or allied forces.

Recovery assets are centrally managed. This provides direction, permits better management, and provides quicker responses to task organization, work load, and the tactical situation. In combat units, the recovery manager is designated at battalion level and is normally the BMO. Some combat arms battalions (that is, nondivisional, defense battalions, engineer battalions, and so forth) have company-sized units that operate without a BMO or BMT. In these type units, the senior maintenance supervisor, motor officer/sergeant, manage recovery assets.

The type and quantity of supported equipment, as well as tactical situation, may require the tailoring of recovery assets. Only the minimum number of recovery assets should be deployed for each mission.

The BMO or other designated individual coordinates recovery operation with overall repair efforts to support the commander's priorities and tactical situation most effectively. The following general principals apply to recovery management:

- Commanders must set recovery priorities.
- Using units are responsible for recovery of their equipment. Limited backup support is available from the next level of maintenance.
- Coordinate recovery operations with the maintenance effort.
- Recovery vehicles of the correct load class must be used to ensure safety.
- Recovery vehicles should not return equipment farther than the UMCP. This keeps recovery assets forward.
- Recovery teams must use NBC contamination avoidance principles to avoid contamination or to minimize targeting.
- Recovery teams should take all practical steps to avoid spills and other environmental contamination.

FUNDAMENTAL METHODS OF RECOVERY

INTRODUCTION

Three questions should come to mind when a soldier faces a recovery task: "What must be done?", "What equipment must be used?", and "What techniques must be used?" This chapter will answer these questions beginning with a summary of the four methods of recovery. It will give details about recovery tackle and how to use and maintain it.

WINCHING, LIFTING, TOWING, EXPEDIENTS

The four methods of recovery are:

- **Winching** - using winches on special purpose or cargo vehicles.
- **Lifting** - using lifting capabilities of special purpose vehicles.
- **Towing** - using the towing capabilities of similar or special purpose vehicles.
- **Expedients** - used when other methods are not adaptable to the situation, or when appropriate like-vehicles or dedicated recovery vehicles are not available.

RECOVERY SAFETY

Recovery can be inherently dangerous unless safety is continually observed and practiced. Each of the recovery functions (winching, lifting, and towing) must only be performed with safety as the primary concern. Always follow safety warnings in this manual and in the operator's manual for both the recovery vehicle and the recovered vehicle or equipment. Following are some key factors and actions that can help prevent unnecessary damage to equipment and more importantly, injury to personnel.

Know recovery equipment capabilities and limitations! Winches have tremendous power and if not properly secured to the disabled vehicle, they can rip off tow lugs, bumpers, and other attachments that often become missiles injuring personnel and/or damaging equipment. Always follow the safe rigging guidelines in this manual. Keep all but the minimum required personnel away from the recovery area. Each recovery crew member must know where other crew members are located at all times.

Ground chocks and spades have their limitations. If overloaded, the recovery vehicle can slide out of control.

Winch cables can break and backlash into personnel.

Exercise extreme caution when towing.

Towed track vehicles and some wheel vehicles will not have any braking effect. The recovery vehicle must provide braking for the towed vehicle as well as itself. Remember, some track vehicles may also require a holdback vehicle during towing operations. Check the operator's manual.

Wrecker lift-towing operations also require extreme caution! The towed vehicle performs abnormally because the vehicle weight is not distributed on all wheels and the wrecker steering control is degraded because of reduced weight on the front wheels.

Other recovery lifting actions also require extreme caution to prevent injury to personnel and/or damage to equipment. Suspended loads can drop or slide. If the crane has a remote control, use it to keep away from the action. The remote control can also assist in observing equipment movement of the recovery actions and location of other crew members. Never exceed the limitations of the crane or its outriggers.

REMEMBER,
DURING RECOVERY OPERATIONS
SAFETY FIRST !

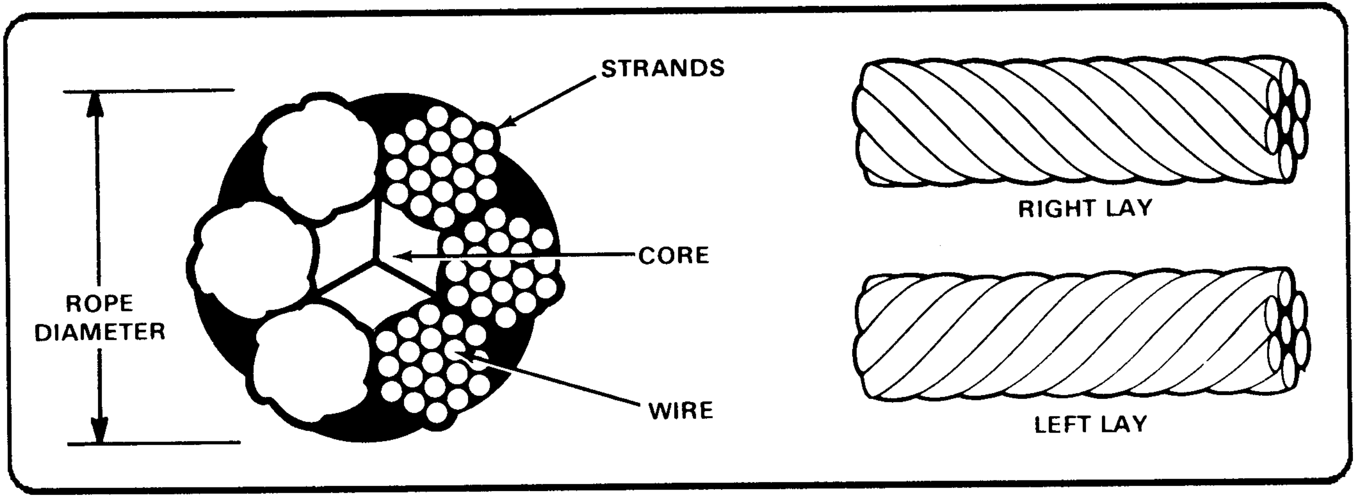


Figure 2-1. Wire Rope

RECOVERY EQUIPMENT

Wire Rope

A wire rope is made of many wires twisted together to make a strand. The strands are then twisted together around a core making a rope. Wire rope is designated by the number of strands per rope and the number of wires per strand.

Example: 6 x 19 rope is 6 strands per rope, 19 wires per strand.

Cores. Wire rope cores are of three types: fiber, strand, and independent. Each type gives support to the strands laid around it. Fiber cores will add flexibility and elasticity to a wire rope. Metallic strand cores will withstand high operating pressures, resist heat, and give minimum stretch and additional strength. However, independent wire rope cores are often used for winches because they add the most strength.

Lay. The lay of wire rope is the combined direction of the lay of the wire in the strand and the direction of lay in the strands on the rope. Wire rope is made with either right or left lay, depending on the direction of the helix of the strands in the rope. In a right-lay rope, the strands are laid around the core from left to right, as in a right-hand screw thread. The strands of a left-lay rope are laid around the core from right to left, as in a left-hand screw thread. In most cases, it makes little difference whether a right- or left-lay rope is used. However, right-lay ropes are recognized as standard for most types of service.

Care and Use. Wire rope should be handled correctly at all times for best service and to prevent injury to personnel. When using wire rope, observe the following precautions.

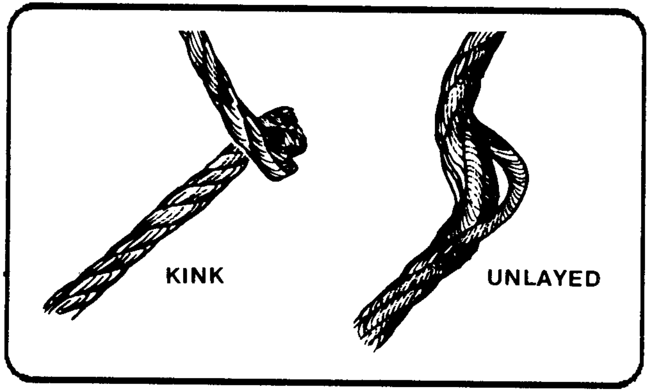


Figure 2-2. Kinking

New rope. When installing new wire rope,work the rope several times under a load so that it can adjust itself to working conditions, i.e. build memory.

Kinks. Avoid all kinks. Kinks make the rope unservicable. A kink cannot be straightened by pulling the rope taut since this merely unlays the rope.

Miscellaneous. Avoid pulling rope around small trees or flat surfaces since this causes strands to spread. Avoid using wire rope on sheaves that are too

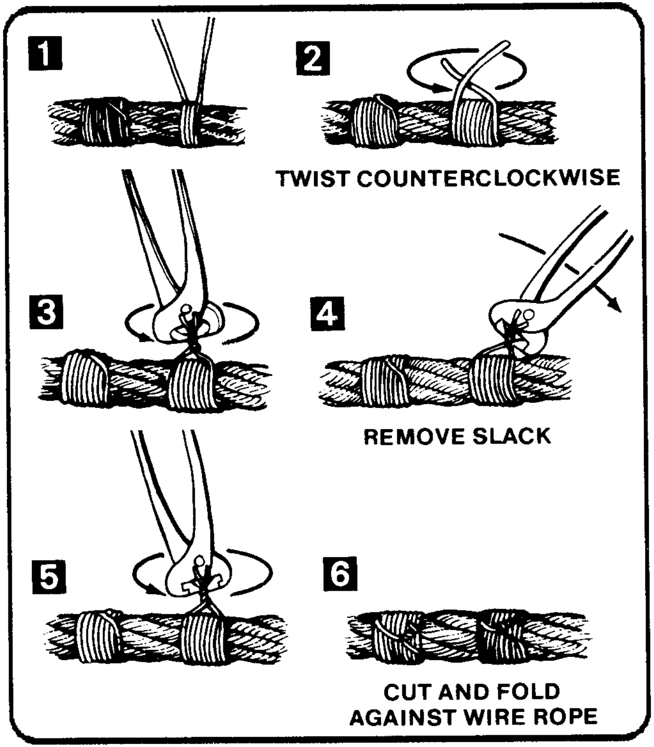


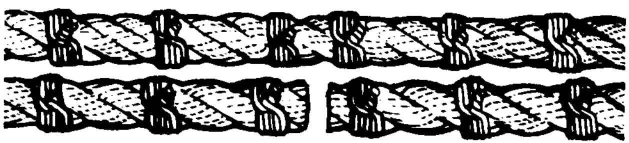
Figure 2-3. Seizing Wire Rope

small since this breaks wire in the strands and weakens the rope.

Wire rope lubrication. Be sure to lubricate wire rope which is in service. Lubrication protects the rope against corrosion, reduces friction within the rope, expels moisture, and preserves the rope. Wire rope is lubricated when manufactured, but requires periodic lubrication. Check the appropriate vehicle technical manual for type and interval of lubrication.

Seizing wire rope. Always bind the ends of wire rope to prevent strands and wire from untwisting. Before cutting wire rope, it is necessary to bind it. The seizing method is recommended when special fittings are not available. to the rope by hand. Keep the coils tight and the rope under tension. Twist the ends of the seizing wire counterclockwise, and tighten the twist enough to remove slack. The number of wraps for each end of the wire rope should be three times the diameter of the rope in inches. They should be made the same length as the diameter of the rope, and spaced a distance equal to twice the diameter of the rope.

WARNING:
When seizing wire rope, it is important to be safety conscious. Cables or wire ropes can become damaged through use. Personnel should always wear heavy gloves with leather palms when handling wire rope or cable to minimize potential injury. Gloves will prevent hands from being injured or cut because of broken wires.



- SEIZES SAME LENGTH AS DIAMETER OF ROPE
- SPACE SEIZES EQUAL TO TWICE THE DIAMETER OF THE ROPE

Figure 2-4. Cutting Wire Rope

Cutting: After seizing, wire rope may be cut by any of the following means:

- A special wire rope cutter and sledge hammer.
- A long tapered chisel and sledge hammer. (The chisel must be wider than the rope being cut.)
- A bolt cutter (small rope only).
- A hacksaw.
- An oxyacetylene cutting torch if rope is not to be spliced. This is a dangerous procedure. Exercise extreme caution.

Wire Rope Attachment

Fittings or end attachments for wire rope vary with use. The standard fittings for field use are thimbles and clips. Splicing is not practical in the field.

Thimbles. Thimbles are used in the loop formed when the rope is attached to the eye of hooks or

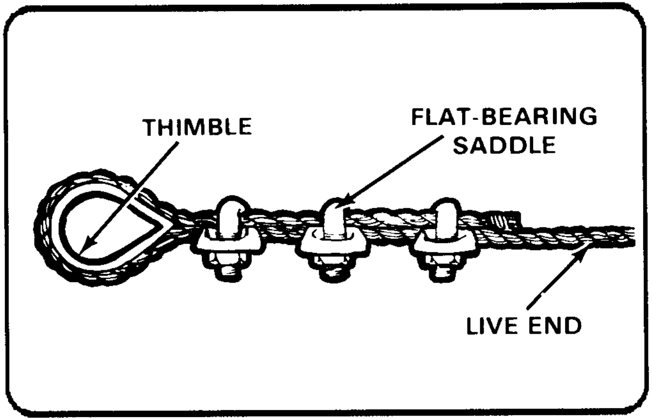


Figure 2-5. Thimbles and Clips

rings. Thimbles keep wire in the strand from shearing and breaking when stress is applied.

Clips. When attaching clips, place all the U-bolts on the short or dead end of the rope. This protects the live or stress-bearing end of the rope from possible crushing and abuse. The flat-bearing saddle or base and extended prongs of the body are designed to protect the rope and should always be placed against the live end. If clips are incorrectly installed, they will cause shearing, extensive wear, and breakage.

To determine the number of clips, torque, and spacing, refer to Table 2-2 of TM 5-725.

Fiber Rope

Fiber rope is generally referred to as cordage and consists of vegetable or synthetic fibers twisted together. Vegetable ropes are usually made of sisal or hemp fibers. Today most ropes are made of nylon fibers. These ropes are preferred because their tensile strength is nearly three times that of natural fibers. Nylon ropes are waterproof, return to normal size after being stretched, and resist abrasion, rot, decay, and fungus growth.

The strength and useful life of rope will be shortened considerably by lack of maintenance. It should be stored in a cool, dry place. Avoid dragging the rope through sand, grit, or bending it across sharp surfaces.

Inspect by untwisting strands slightly to open the rope for examination. Mildewed ropes will have a

THE SAFE WORKING CAPACITY OF A ROPE CAN BE OBTAINED BY SQUARING THE DIAMETER OF THE ROPE IN INCHES

musty odor, and inner fibers of the strand will have a dark appearance. Unserviceable ropes should be cut in small pieces to prevent their use for hoisting.

See Table 1-1, TM 5-725, for a detailed listing of the properties of manila and sisal rope. As a general rule, the safe working capacity (SWC) of a rope can be obtained by squaring the diameter of the rope in inches ($SWC = d^2$). This formula gives SWC in tons, allowing a safety factor of approximately four.

Example: SWC of a 1/2-inch rope is .5 x.5 = .25 tons.

BLOCKS

Blocks consist of a shell or frame with one or more grooved wheels called sheaves. Two basic constructions (snatch and conventional) are used in the military.

Snatch Block

A snatch block is used when it will not be a permanent part of a tackle system (ropes, blocks, and pulleys used to raise and lower loads and/or apply tension) and can be used as required based on the situation. It is constructed so that the shell can be opened to admit a cable without reeving. Winch cables have attachment-like hooks or sockets on their free ends and can be reeved through a block.

Conventional Block

A conventional block is generally used where it will remain as part of a rigging system. On recovery equipment, it is used with fiber rope. To form a

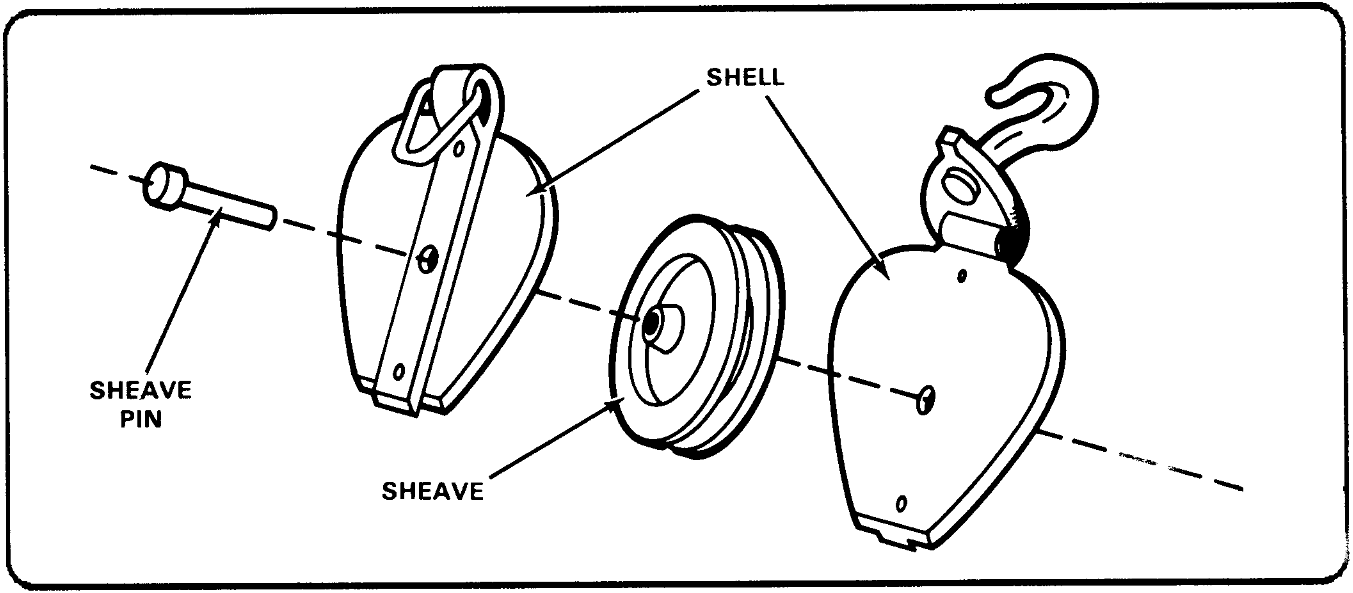


Figure 2-7. Block Components

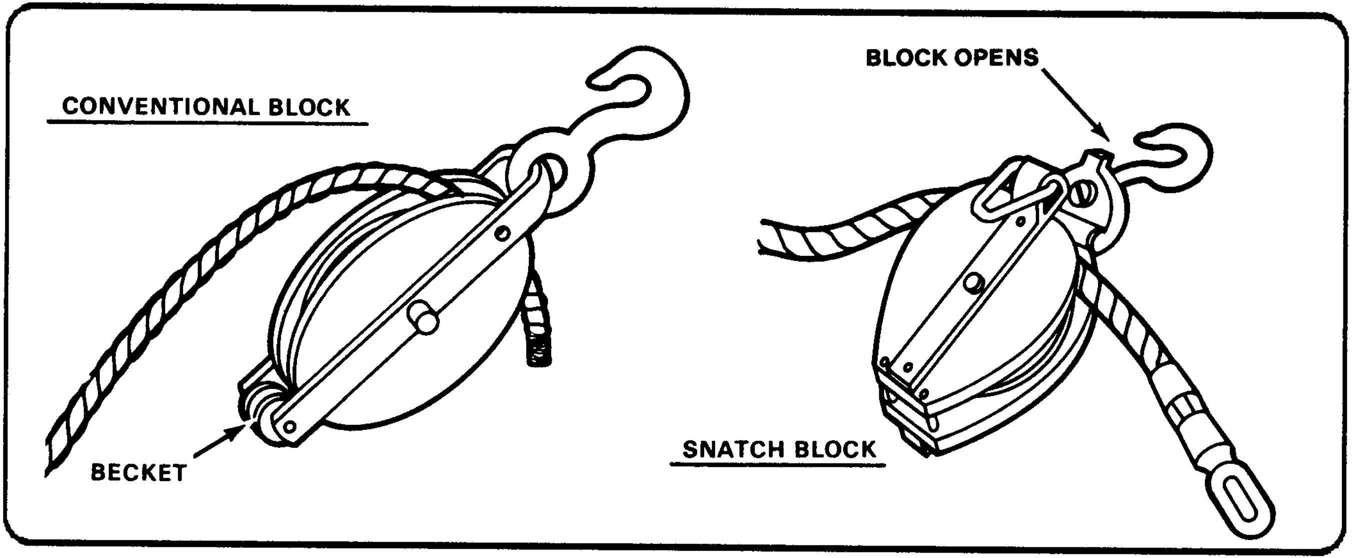


Figure 2-8. Block Configurations

tackle with conventional blocks, lay out the blocks, and thread or reeve the rope through the blocks.

Blocks have the following applications:

- A fixed block is a block attached to a stationary anchor. The sheave of a fixed block permits the rope to change direction.

- A running block is a block that is attached to and moves the load.

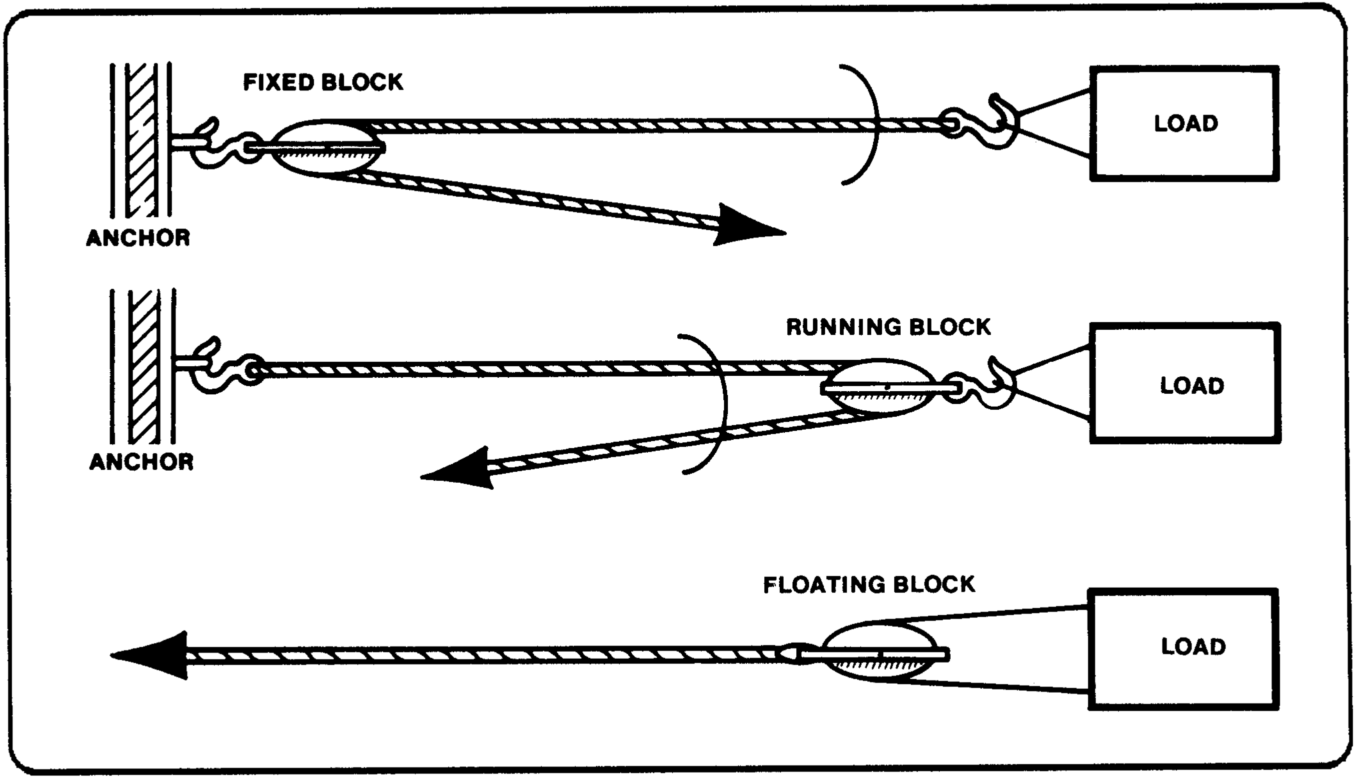


Figure 2-9. Block Classification

A FLOATING BLOCK ALLOWS PULL TO BE DISTRIBUTED EQUALLY TO BOTH TOW HOOKS OF A DISABLED VEHICLE

- A floating block is a block used with a tow cable allowing the cable when pulled to align with the power source. The pull can be distributed equally to both tow hooks of the disabled vehicle.

CHAINS

A chain is made of series of links fastened through each other. Each link is made of metal stock bent into

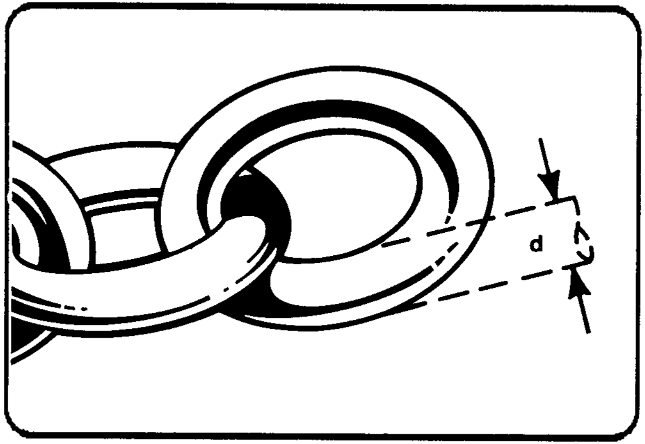


Figure 2-10. Measuring Chain Diameter

an oval shape and welded together. The chain is a major component of many recovery devices such as winch cable assemblies and safety chain assemblies.

The strength of a chain is measured using the formula, SWC = $8d^2$, where SWC = the safe working capacity in tons; d = the diameter of the chain stock in inches.

Example: SWC of a chain with a diameter of 1/2-inch is 8 x .5 x .5 = 2 tons.

Chains stretch and wear under excessive loading. Bent links and damaged welds indicate that a chain has been overloaded. Unlike cable, which fails a wire at a time chain fails all at once giving no warning of impending failure. Keep chains clean and lubricated. Inspect before using for bent links, corrosion, or worn spots. Remove worn or damaged chains from service. Do not paint chains; this restricts chain movement. Store in dry, well-ventilated places to prevent rusting.

HOOKS

Hooks are used as attachments on chains, wire rope, fiber rope, and blocks. The hook affords a means of hauling or raising loads without connecting directly to an object with rope or chain. Hooks may straighten and drop the load when overloaded. If they show cracks or excessive wear, discard them. The inside of a hook is usually an arc of a circle. If it has spread or straightened, discard it. The diameter is measured at the point where the hook starts to take the shape of an arc. Hooks should not be used to apply force or lift loads by bearing directly against the point of the hook. When hooks are used, the opening of the hook faces up so if the hook spreads open, the force will go down.

FIFTH WHEEL TOWING DEVICE (FWTD)

The FWTD, when mounted on a fifth-wheel-type tractor, will enable the tractor to function as a lift/tow vehicle. The FWTD will not replace wreckers, but will provide needed road towing capabilities. The FWTD will be used primarily in all geographical areas where medium/heavy administrative and tactical wheel vehicles operate.

ALLIED KINETIC ENERGY RECOVERY ROPE

The AKERR is a multistrand, woven, nylon rope used for like-vehicle recovery. The rope is connected between the mired vehicle and the towing vehicle. The towing vehicle accelerates, stretching the rope, which creates potential energy. When the rope is fully stretched, it transfers the energy to the mired vehicle giving it a strong, sudden pull.

RESISTANCE

Resistance is defined as opposition to movement. In recovery operations, resistance is caused most often by terrain factors such as mud, sand, water, or the recovery tackle itself. This section will focus on vehicles disabled by terrain conditions.

There are two factors that can be applied to help reduce resistance. This section shows what they are and how to use them in recovery operations. Reduction factors discussed in this section do not apply to wheel vehicles.

Once load resistance is determined, effort must be applied to effect recovery. The third section discusses fundamentals of mechanical advantage.

TYPES OF RESISTANCE

Five types of resistance may occur in recovering vehicles disabled by terrain conditions. They are:

Grade Resistance

Grade resistance occurs when a vehicle moves up a slope. Grade resistance (including nosed-in vehicles) is estimated as equal to the weight of the vehicle plus cargo.

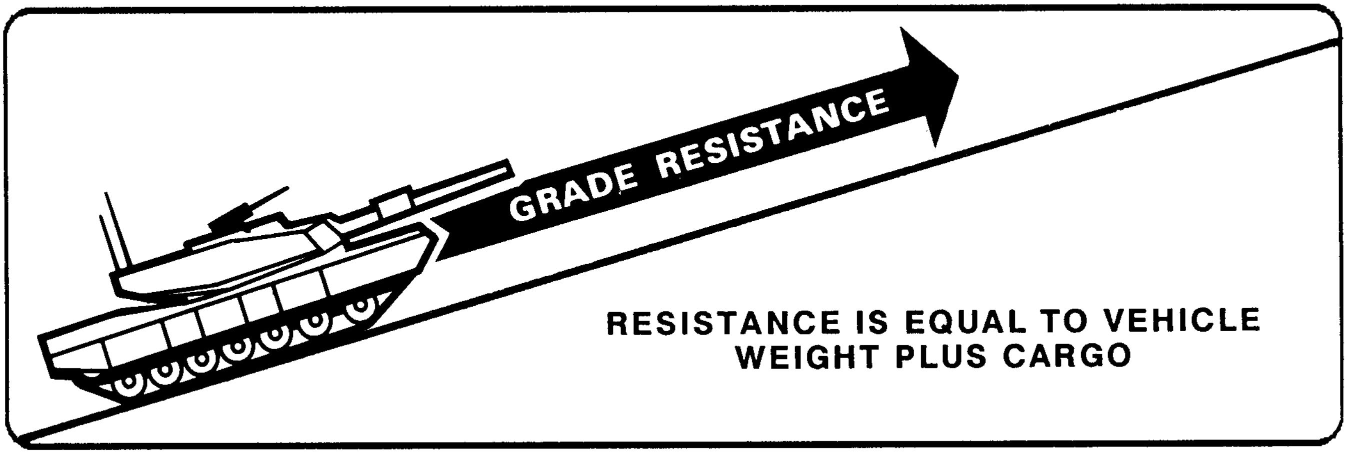


Figure 2-11. Grade Resistance

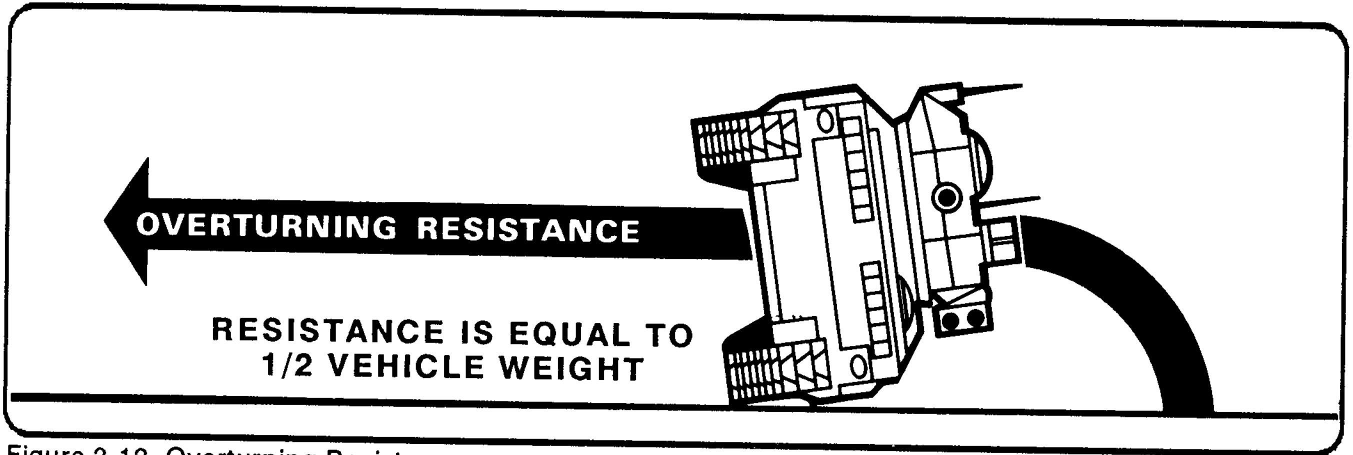


Figure 2-12. Overturning Resistance

Overturning Resistance

Overturning resistance is that weight of the vehicle that acts against the force exerted to bring it back on its wheels or tracks. This force is approximately half the vehicle's weight.

Mire Resistance

Mire resistance is created when mud, snow, or sand becomes impacted around the wheels, tracks, axle, gear housing, or hull. Mire resistance is described as wheel, fender, or turret/cab depth.

Wheel depth mires occur when wheel vehicles are mired up to the hub but not over the center. Track vehicles are mired up to the road wheels but not over the top. Estimate wheel-depth resistance as equal to the weight of the vehicle plus cargo.

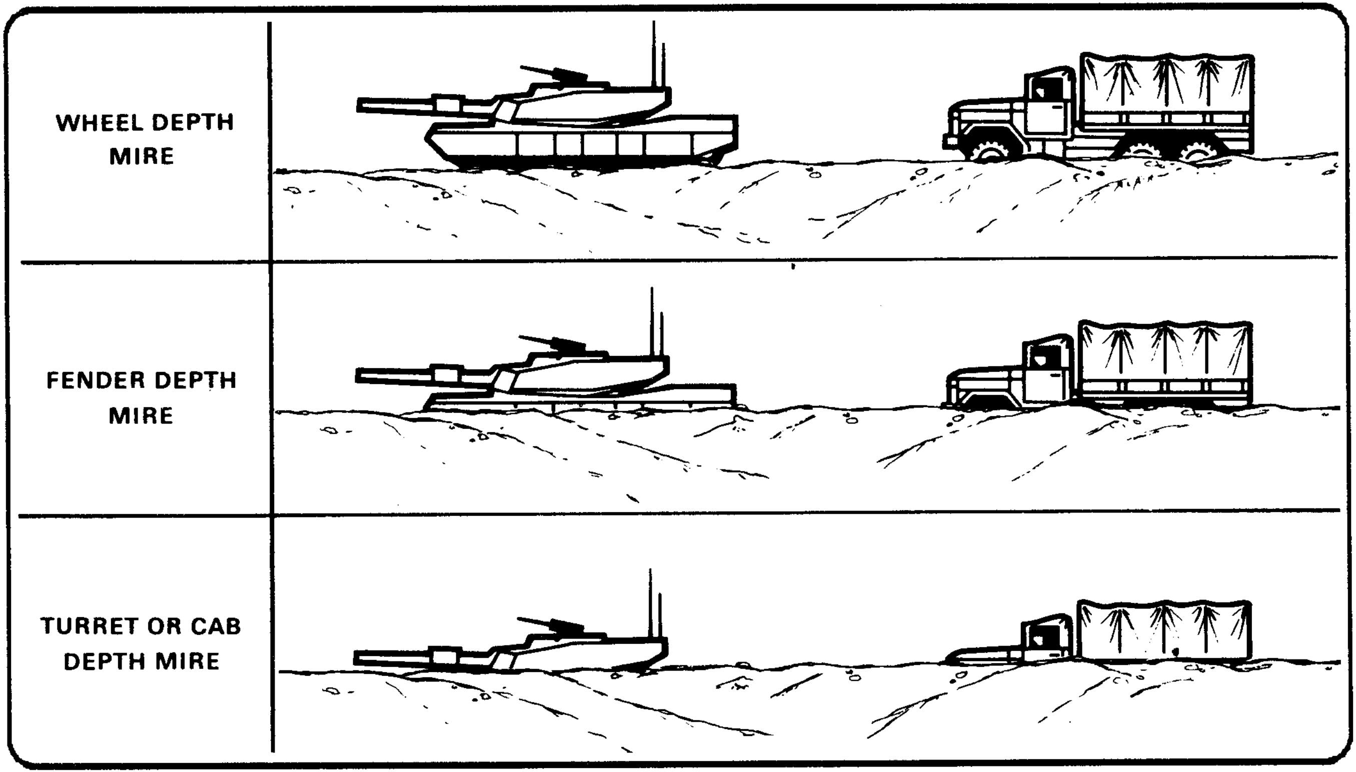


Figure 2-13. Mire Resistance

Fender depth mires occur when wheel vehicles are mired over the top of the hub, but not over the fender, and track vehicles are mired over the top of the road wheels, but not over the fender. Estimate fender depth mire resistance as twice the total weight of the vehicle plus cargo.

Turret or cab depth mires occur when vehicles are mired over the top of the fender. Estimate turret/cab depth mire resistance as three times the total vehicle weight plus cargo.

Water Resistance

Water resistance occurs when submerged vehicles are pulled from water to land. Estimate the amount of resistance met the same way as for land recovery. In some instances, the resistance to overcome is less

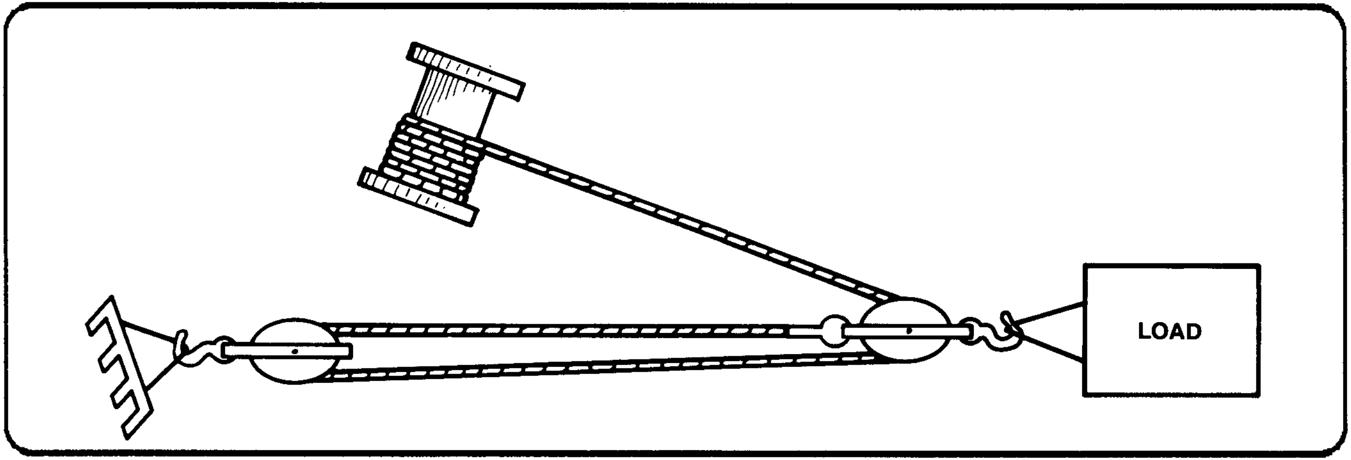


Figure 2-14. Tackle Resistance

than the rolling resistance of the same vehicle on land. See Marine Recovery, Chapter 4, for more information.

Tackle Resistance

Tackle resistance is that part of total resistance that is added to the recovery by friction in tackle. Tackle resistance is estimated as an additional 10 percent (.10) of the load resistance for each sheave used in rigging.

Example: In Figure 2-14, say the load is 40 tons, and two sheaves are used.

LOAD	= 80,000 lb
TACKLE RESISTANCE	= 16,000 lb*
TOTAL RESISTANCE	= 96,000 lb

*2 x .10 x 40 tons

RESISTANCE REDUCING FACTORS

Situation and mechanical resistance affect the load resistance of mired vehicles. However, since wheel vehicle resistances vary because of traction loss, reduction factors will only be applied to track vehicles.

Direction of Travel and Recovery

When a mired vehicle is recovered in the opposite direction of its travel, the tracks pass through ruts the vehicle made going into the mire. This reduces estimated resistance approximately 10 percent and is the preferred method of recovery.

Example: A tank weighing 106,000 pounds is mired at wheel depth and can be recovered in the opposite direction of travel. Estimate resistance as 106,000 pounds and subtract 10 percent for recovery in the opposite direction of travel. The load resistance equals 95,400 pounds

ESTIMATED RESISTANCE	106,000 lb
REDUCING FACTOR	x .10
	10,600 lb

	106,000 lb
	-10,600 lb
ESTIMATED LOAD RESISTANCE	95,400 lb

Power Applied to Tracks

When power is applied to the tracks of a mired vehicle, the movement of the tracks helps to break the suction of mud against the belly of the vehicle. This reduces estimated resistance by approximately 40 percent. Before computing the 40 percent reduction, make sure that the mire is not deep enough to prevent the operation of the vehicle's engine. For example, check the air intake and exhaust.

Example: A tank weighing 106,000 pounds is mired at fender depth. It cannot be recovered in the opposite direction of its original travel, but can apply power to its tracks. Estimated resistance (twice the weight of the vehicle) is 212,000 pounds, less 40 percent. The load resistance equals 127,200 pounds.

VEHICLE WEIGHT	106,000 lb
MIRED FACTOR (FENDER DEPTH)	x 2
RESISTANCE	212,000 lb
REDUCTION FACTOR (40% FOR POWER TO TRACK)	x .40
ESITIMATED REDUCTION	84,800 lb

	212,000 lb
	-84,800
ESTIMATED LOAD RESISTANCE	127,200 lb

Example: A tank weighing 106,000 pounds is mired at fender depth. It can be recovered in the opposite direction of its original travel and can apply power to its tracks. Estimated resistance (twice the weight of the vehicle) is 212,000 pounds, less 50 percent (10 percent for opposite direction, plus 40 percent for applying power to its tracks). The load resistance equals 106,000 pounds.

VEHICLE WEIGHT	106,000 lb	
MIRED FACTOR	x 2	
RESISTANCE	212,000 lb	
*REDUCTION FACTOR	x .50	
ESTIMATED REDUCTION	106,000 lb	LOAD
	212,000 lb	
	-106,000 lb	
ESTIMATED LOAD RESISTANCE	106,000 lb	

*40% POWER TO TRACK PLUS 10% RECOVERING OPPOSITE DIRECTION TO TRAVEL

NOTE 1: Reduction factors do not apply to wheel vehicles due to lack of traction. However, power applied to wheels may reduce resistance.

NOTE 2: Reduction factors are only a guide and apply more to wheel depth versus either fender or turret depth mire situations.

SOURCES OF EFFORT

Similar vehicles are the quickest and most available sources of recovery effort. On dry, level hardstand in first gear and reverse, the average vehicle exerts a force equal to its own weight. Terrain conditions affect the towing capability of a vehicle. These conditions may require two or more vehicles to exert the same force that one vehicle could under ideal conditions. When the situation does not permit recovery by a similar vehicle, use a winch. The most common situation occurs when the approach to the disabled vehicle does not provide good traction. A winch is a more positive source of effort since its capacity does not depend on terrain conditions.

A winch exerts its greatest force when it pulls by the first layer or the layer next to the bare winch drum. As each successive layer of cable is wound onto the winch drum, the diameter increases and the

TABLE 2-1
WINCH VARIABLE CAPACITIES

Winch Type	Cable Layer	Cable on Drum (ft)	Capacity (tons)
5 Ton	1	0 - 39	5.000
	2	40 - 85	4.225
	3	86 - 138	3.670
	4	139 - 199	3.230
	5	200 - 266	2.890
10 Ton	1	0 - 41	10.000
	2	42 - 91	8.450
	3	92 - 148	7.250
	4	149 - 213	6.400
	5	214 - 287	5.700
22.5 Ton	1	0 - 42	22.500
	2	43 - 93	18.850
	3	94 - 153	16.250
	4	154 - 220	14.250
	5	221 - 296	12.650
	6	297 - 380	11.400
30 Ton	1	0 - 55	30.000
	2	56 - 128	26.000
	3	129 - 208	23.000
	4	209 - 300	20.000
45 Ton	1	0 - 41	45.000
	2	42 - 91	38.000
	3	92 - 149	32.500
	4	150 - 200	28.500

NOTE: THE 70 TON IRV HAS A CONSTANT CAPACITY OF 70 TONS ANYWHERE ON CABLE.

winch capacity decreases. An exception is the constant pull winch found on the M88A2 where the force of pull remains constant regardless of the cable layer.

MECHANICAL ADVANTAGE (MA)

Overcoming Resistance

Applying effort to overcome resistance has always been a challenge to mankind. Modern machinery is evidence of this. Energy released by burning small amounts of fuel in a modern engine provides the effort to move trucks weighing thousands of pounds. The truck engine, with various mechanical devices, can move the vehicle from a standstill through a wide range of speeds.

Mechanical Advantage

Mechanical advantage is a small amount of force applied over a long distance to move a heavy load a short distance. Mechanical advantage is needed whenever the load resistance is greater than the capacity of the available effort.

To determine the amount of mechanical advantage (MA) necessary in a recovery operation, divide the load resistance (LR) by the available effort (AE) and round any fraction to the next whole number. Rounding is required because only whole numbers can be rigged.

$$\frac{\text{LR} = 106{,}000 \text{ lb (LOAD)}}{\text{AE} = 90{,}000 \text{ lb (WINCH)}} = 1.1777$$

Round the fraction off to the next whole number.

REQUIRED MECHANICAL ADVANTAGE = 2:1

Leverage Principle

The use of levers is the most basic means to overcome resistance. A wrench handle, a can opener, and the gears of a truck overcome resistance by applying the principles of leverage. The simplest form of a lever is a rigid bar free to turn on a fixed pivot called a fulcrum. When effort is exerted on one end of the bar, the bar rotates around the fulcrum. Mechanical advantage is increased by extending the distance between the point where effort is applied and the fulcrum.

Lever Classification

Levers are divided into two classes. The location of the fulcrum with relation to effort and resistance determines the class of lever.

- **First-class lever:** The fulcrum is located between the effort and the resistance. A crowbar is a good example of a first-class lever.

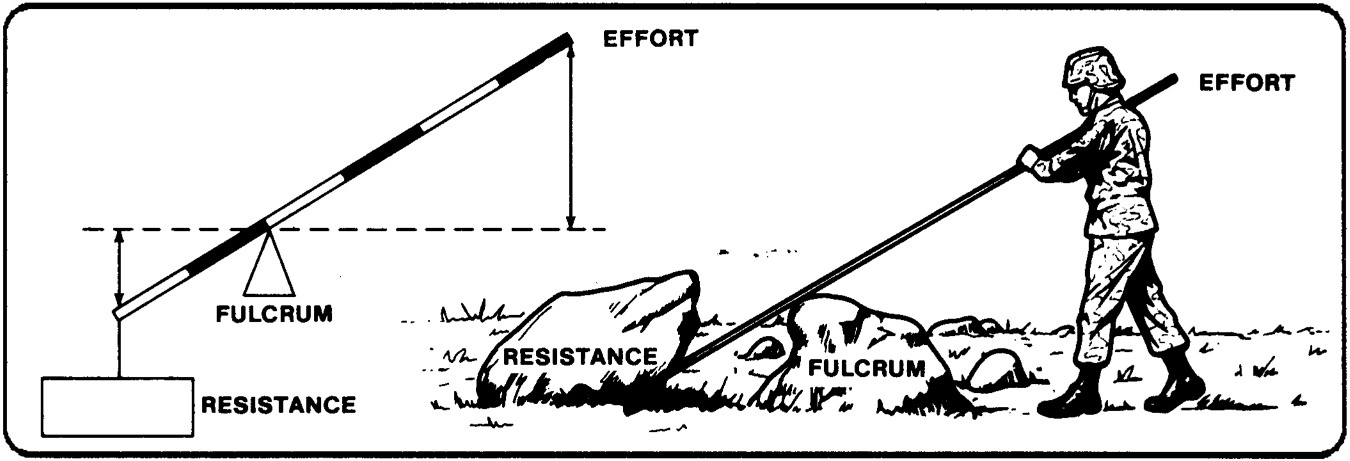


Figure 2-15. First Class Lever

- **Second-class lever:** The point of resistance is between the fulcrum and the effort. A wheelbarrow is a good example of a second-class lever.

Tackle

Tackle is a combination of ropes or cables and blocks used to gain a mechanical advantage or to change direction of pull. Tackle is classified as

- **Simple tackle:** Simple tackle is one rope or cable with one or more blocks.

- **Compound tackle:** Compound tackle is a series of two or more simple tackles. The output of one simple tackle is used as the effort for the other. Since a winch has only one cable, simple tackle will almost always be used during recovery operations.

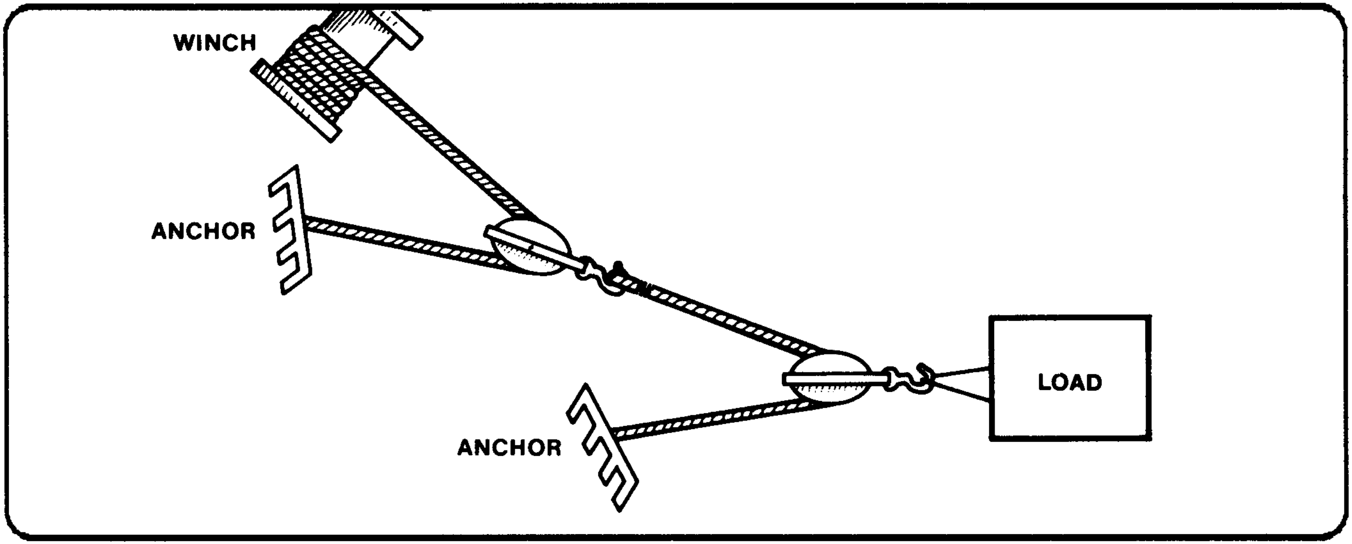


Figure 2-16. Compound Tackle